

WHAT IS CLAIMED IS:

1. An illumination optical system, comprising:  
a luminous intensity distribution converting  
optical system for converting an illuminance  
distribution of a light source image into a luminous  
intensity distribution upon a predetermined plane;  
a total reflection type light transmitting  
element having its light entrance surface disposed  
substantially in coincidence with the predetermined  
plane; and  
a light collecting optical system for  
defining an illumination region upon a surface to be  
illuminated, by use of light from said light  
transmitting element.

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2. An illumination optical system according to  
Claim 1, wherein the illuminance distribution of the  
light source image has an intensity which is higher at  
a portion adjacent to an optical axis than the  
intensity at a peripheral portion thereof.

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3. An illumination optical system according to  
Claim 1, further comprising a light source, and light  
source image forming means for forming the light  
source image by use of light from the light source.

4. An illumination optical system according to

Claim 3, wherein said light source image forming means includes an elliptical mirror having a focal point whereat the light source is disposed, and wherein the light source image is formed at another focal point of said mirror.

5           5. An illumination optical system according to Claim 3, wherein the light source comprises a Hg lamp.

10          6. An illumination optical system according to Claim 1, said converting optical system includes first and second lens units having the same focal distance and being disposed so that a distance between principal points of the two lens units becomes equal 15 to the focal distance, and wherein an entrance pupil of the first lens unit is disposed substantially in coincidence with the light source image while an exit pupil of the second lens unit is disposed substantially in coincidence with the predetermined plane.

20          7. An illumination optical system according to Claim 1, wherein said converting optical system includes an optical rod and a lens unit, wherein a light entrance surface of the optical rod is disposed substantially in coincidence with the light source image, and wherein one focal point position of the

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~~lens unit is disposed substantially in coincidence with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.~~

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8. An illumination optical system according to  
Claim 1, wherein said converting optical system  
includes a fly's eye lens and a lens unit, wherein a  
10 light entrance surface of the fly's eye lens is  
disposed substantially in coincidence with the light  
source image, and wherein one focal point position of  
the lens unit is disposed substantially in coincidence  
with a light exit surface of the fly's eye lens, while  
another focal point position of the lens unit is  
15 disposed substantially in coincidence with the  
predetermined plane.

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9. An illumination optical system according to  
Claim 1, wherein said light transmitting element  
comprises an optical fiber bundle.

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10. An illumination optical system according to  
Claim 9, wherein the optical fiber bundle has a light  
entrance face of one of square shape and rectangular  
shape, and a light exit face of arcuate shape.

11. An illumination optical system, comprising:  
a luminous intensity distribution converting  
optical system for converting an illuminance  
distribution of a light source image into a luminous  
intensity distribution upon a predetermined plane;  
an optical fiber bundle having its light  
entrance surface disposed substantially in coincidence  
with the predetermined plane; and  
a light collecting optical system for  
defining an illumination region upon a surface to be  
illuminated, by use of light from said optical fiber  
bundle.

12. An illumination optical system according to  
Claim 11, wherein the illuminance distribution of the  
light source image has an intensity which is higher at  
a portion adjacent to an optical axis than the  
intensity at a peripheral portion thereof.

13. An illumination optical system according to  
Claim 11, further comprising a light source, and light  
source image forming means for forming the light  
source image by use of light from the light source.

14. An illumination optical system according to  
Claim 13, wherein said light source image forming  
means includes an elliptical mirror having a focal

point whereat the light source is disposed, and wherein the light source image is formed at another focal point of said mirror.

5        15. An illumination optical system according to  
Claim 13, wherein the light source comprises a Hg  
lamp.

10      16. An illumination optical system according to  
Claim 11, said converting optical system includes  
first and second lens units having the same focal  
distance and being disposed so that a distance between  
principal points of the two lens units becomes equal  
to the focal distance, and wherein an entrance pupil  
of the first lens unit is disposed substantially in  
coincidence with the light source image while an exit  
pupil of the second lens unit is disposed  
substantially in coincidence with the predetermined  
plane.

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17. An illumination optical system according to  
Claim 11, wherein said converting optical system  
includes an optical rod and a lens unit, wherein a  
light entrance surface of the optical rod is disposed  
substantially in coincidence with the light source  
image, and wherein one focal point position of the  
lens unit is disposed substantially in coincidence

with a light exit surface of the optical rod, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

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18. An illumination optical system according to Claim 11, wherein said converting optical system includes a fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

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15. An illumination optical system according to Claim 11, wherein said converting optical system includes a fly's eye lens and a lens unit, wherein a light entrance surface of the fly's eye lens is disposed substantially in coincidence with the light source image, and wherein one focal point position of the lens unit is disposed substantially in coincidence with a light exit surface of the fly's eye lens, while another focal point position of the lens unit is disposed substantially in coincidence with the predetermined plane.

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19. An illumination optical system according to Claim 11 wherein said optical fiber bundle has a light entrance face of one of square shape and rectangular shape, and a light exit face of arcuate shape.

25. An illumination optical system according to Claim 11, wherein said optical fiber bundle comprises a total reflection type optical fiber bundle.

21. An illumination optical system according to

Claim 11, wherein said optical fiber bundle comprises  
a distributed refractivity type optical fiber bundle.

22. An illumination optical system, comprising:

5 a luminous intensity distribution converting  
optical system for converting a luminous intensity  
distribution of plural light fluxes having different  
incidence angles into an illuminance distribution upon  
a predetermined plane;

10 a total reflection type light transmitting  
element having its light entrance surface disposed  
substantially in coincidence with the predetermined  
plane; and

15 a light collecting optical system for  
defining an illumination region upon a surface to be  
illuminated, by use of light from said light  
transmitting element.

23. An illumination optical system according to  
20 Claim 22, wherein said light transmitting element  
comprises an optical rod.

24. An illumination optical system according to  
Claim 22, wherein the plural light fluxes are supplied  
25 by a plurality of laser light sources.

25. An exposure apparatus, comprising:

an illumination optical system as recited in  
any one of Claims 1 - 24; and

5 a projection optical system for transferring,  
by exposure, a pattern of a mask as illuminated with  
said illumination optical system, onto a wafer.

26. A device manufacturing method, comprising the  
steps of:

10 applying a resist to a wafer;  
transferring, by exposure, a pattern of a  
mask onto the wafer by use of an exposure apparatus as  
recited in Claim 25; and  
developing the wafer having the pattern  
transferred thereto.

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